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SURVIVAL OF DIPTERAN PARASITOIDS (DIPTERA: TACHINIDAE) DURING A VIRUS-INDUCED GYPSY MOTH POPULATION COLLAPSE

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Abstract.—A population of gypsy moth, *Lymantria dispar* (L.), in Garrett County, Maryland was examined for parasitoids and infection of *Lymantria dispar* nucleopolyhedrosis virus (LdMNPV). Total parasitism was 19.5% and 22.8% for two cohorts of gypsy moth and over 70% of the parasitized larvae were also infected with virus. *Compsilura concinnata* (Meigen) was the most common of three tachinid species recovered. The tachinid parasitoids appear to be at least tolerant of virus infection in the host; however, their development may be influenced by a stressed host.

Key Words: *Lymantria dispar*, LdMNPV, Tachinidae, parasitoids

Several parasitoid species have been reported in association with *Lymantria dispar* (L.) in North America since its accidental introduction in the 19th century. Their presence is a result of intentional introduction of parasitoids in early attempts at biological control of the gypsy moth (Doane and McManus 1981). The *Lymantria dispar* nucleopolyhedrosis virus (LdMNPV) is an important pathogen of the gypsy moth that has also become established in North America (Lewis 1981). Interest in interactions and interrelationships between LdMNPV and other organisms has been raised, especially since the virus has been investigated as an agent for suppression of gypsy moth (Lewis and Podgwaite 1981, Podgwaite at al. 1981).

METHODS

We assessed levels of parasitism in a gypsy moth population in Garrett County, Maryland, at a site where the composition of tree species was oak (*Quercus* spp.)/mixed hardwood. The gypsy moth population appeared to be collapsing from an LdMNPV epizootic. These observations were made in 1991 as part of a field experiment to determine activity of a spray adjuvant (enhancing agent) with a formulation of LdMNPV (Gypchek). Evaluation of larvae collected from test plots before treatment indicated that greater than 18% of the collected larvae were fatally infected with naturally occurring LdMNPV. A larval survey found instars 1, 2, and 3 at the time of spray application, which was May 21, 1991. Proportions of third instars were 60% and 69% at two survey areas; second instars comprised 24% and 28% of the survey samples. Cohorts of gypsy moth larvae were collected randomly 19 days (n = 960) and 28 days (n = 940) after ground-based hydraulic application of the virus formulation and held individually in 30 ml diet cups in field insectaries. Larval mortality was monitored weekly beginning June 20, and all dead specimens were returned to the laboratory where they were frozen and later examined for LdMNPV infection and parasitism. The diet cups were examined for the presence of

Table 1. Number of parasitized gypsy moth larvae, by parasitoid species, Garrett County, Maryland, 1991.

Cohort*	D-19 (n = 960)		D-28 (n = 940)	
	Ld-MNPV Infected	Not Infected	Ld-MNPV Infected	Not Infected
Compsilura concinnata	124	29	93	26
Exoristini**	4	8	20	21
Blepharipa pratensis	3	0	6	12
C. concinnata + Exoristini	2	2	1	1
C. concinnata + *B. pratensis*	0	2	0	0
C. concinnata + *Cotesia melanoscela*	2	1	0	2
Diptera, undetermined	5	4	32	0
Cotesia melanoscela	19	6	3	5
Hymenoptera, undetermined	3	1	0	0
Total parasitized	162	53	155	67

* Cohorts were collected 19 and 28 days from date of spray application.

** Presumed to be *Parasetigena silvestris*. Species in Exoristini cannot be determined from puparium (Sabrosky and Reardon 1976).

parasitoids that had exited the host, and dead gypsy moth larvae were dissected to determine if parasitoids were present. Temporary wet mounts of larval tissue were examined under a light microscope for the presence of viral occlusion bodies. Data from the necropsies are summarized in Tables 1 and 2.

Results and Discussion

Levels of parasitism in gypsy moth larvae by dipteran species were 19.5% for those collected on day 19 and 22.8% in those collected on day 28 (Table 1). Parasitism by hymenopterous parasitoids was 3.3% and 1.1%, respectively. Of the gypsy moth larvae parasitized by Diptera, 73.9% and 70.8% were also infected with LdMNPV in the respective cohorts. In addition to parasitism and virus infection, there was some mortality from undetermined causes (day 19 = 13.0%; day 28 = 5.2%). Survivorship of the gypsy moth larvae in the two cohorts was 14.3% for larvae collected on day 19 and 25.7% for larvae collected on day 28. *Compsilura concinnata* (Meigen) was the species for which superparasitism occurred most frequently, with 42 host specimens superparasitized by this species. In most instances there were 2 per host; however, there were 5 hosts that had 3 individuals of this species and one caterpillar produced 6 *C. concinnata* puparia. Also, there were 2 instances where *C. concinnata* was found in the same host with *Blepharipa pratensis* (Meigen), 6 occurrences with *Parasetigena silvestris* (Robineau-Desvoidy), as well as 5 instances with *Cotesia melanoscela* (Ratzeburg) (Hymenoptera: Braconidae). Since only 12.3% of the dipteran parasitoids were found as larvae within a dead host (Table 2), it seems likely that in a situation where all the hosts were infected with LdMNPV, parasitism could still be successful at levels similar to those observed in this study. Two-way contingency tests for each cohort indicate that the occurrence of virus infection and parasitization are significantly associated (all parasitoid species combined) ($\chi^2 = 7.362$, $P = 0.007$ for cohort D-19; $\chi^2 = 8.599$, $P = 0.003$ for cohort D-28).

Compsilura concinnata, the predominant species recovered in our study, has a reported host range of over 200 species (Sabrosky and Reardon 1976). It may be more efficient at finding and parasitizing instars 1–3 in low to moderate density populations (Weseloh 1982), but is capable of parasitizing later instars and can be a significant cause of mortality in the later larval stages (Gould et al. 1990). Our findings of a slight decrease in recovery of *C. concinnata* in the day-28 cohort over the day-19 cohort are perhaps a reflection of mortality of parasitized larvae that occured between collection dates. *Cotesia melanoscela*, a parasitoid of early instars (Doane and McManus 1981), was seen more frequently in the larvae collected on day 19.

Parasetigena silvestris and *Blepharipa pratensis* are host specific and successfully parasitize only late instar gypsy moth larvae

Table 2. Dipteran parasitoids recovered from gypsy moth hosts, LdMNPV-infected and not infected, Garrett County, Maryland, 1991. Parasitoids that had not pupated are listed in brackets.

Cohort	D-19		D-28	
	Host Infected	Host Not Infected	Host Infected	Host Not Infected
Compsilura concinnata	148 [0]	37 [0]	108 [3]	42 [0]
Exoristini	6 [0]	10 [0]	26 [8]	23 [2]
Blepharipa pratensis	3 [1]	2 [1]	7 [4]	12 [0]
Diptera, undetermined	5 [3]	4 [4]	32 [31]	0 [0]
Totals	162 [4]	53 [5]	173 [46]	77 [2]

(Sabrosky and Reardon 1976, Godwin and ODell 1981). They are physically unable to complete development in smaller hosts. The increase in parasitism by these species of the larvae collected on day 28 versus larvae collected on day 19 reflects synchrony of their life cycles with that of the host.

Laboratory studies as well as field evidence suggest that parasitoids and other organisms found in the gypsy moth habitat may play a role in the transmission and spread of LdMNPV (Podgwaite et al. 1981). *Cotesia melanoscela* has been shown to be an effective mechanical vector during oviposition (Raimo et al. 1977); presumably *C. concinnata* can also transmit the virus because of the invasive nature of oviposition (Culliney et al. 1992). Although it has been demonstrated that *C. melanoscela* is not affected adversely by an infection of LdMNPV in its host (Lewis and Podgwaite 1981), aerial application of LdMNPV (as Gypchek) has been shown to negatively impact *C. melanoscela* populations (Webb et al. 1989).

Information derived from this study suggests that tachinid parasitoids are at least tolerant of LdMNPV infection in the host. This conclusion is based on the high proportion of host larvae that were virus-infected, but from which parasitoids successfully emerged, and the observation that most parasitoids appeared to be developing normally at the time they were frozen for storage. However, infection of LdMNPV in the gypsy moth population probably does affect the parasitoid populations. Weseloh (1984) demonstrated that several factors influenced the speed of development of *C. concinnata*. When host larvae were stressed by exposure to a *Bacillus thuringiensis* insecticide (Dipel 4-L®) the result was shorter developmental time and increased mortality for this parasitoid. The decrease in *C. concinnata* recovered from the day 28 cohort can perhaps be partially explained by a similar occurrence in hosts that were stressed and killed by LdMNPV infection. The other tachinids, *P. sylvestris* and *B. pratensis*, are probably also affected by a virus infection in the host. In a laboratory study, Godwin and Shields (1984) observed reduced survival of *B. pratensis* coupled with enhancement of viral infection in the host when the eggs and viral inoculant were ingested within one half hour of each other. Since their larval development occurs in the host's late instars (Fuester et al. 1983, Godwin and ODell 1981, Sabrosky and Reardon 1976), these two parasitoids would be likely to compete with the virus for nutrients since infection often is peaking at this time (Woods and Elkinton 1987). In virus-infected hosts, we found proportionally more *P. sylvestris* and *B. pratensis* that had not pupated (Table 2). This suggests such an occurrence.

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